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Assessing Innovation Networks in Nanotechnology

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Abstract

Nanotechnology is regarded as the key technology for the 21st century, affecting almost every aspect of the economy. It has a great potential to stimulate various industries through the advancement of science and technology. Considering that the nanotechnology involves several areas of knowledge, it needs multidisciplinary teams, and for consequence innovation networks.

Innovation networks and specially in the public sector are considered as critical policy instruments to promote the creation and fortification of robust innovation systems, like platforms of learning for the actors.. They constitute themselves in integral element in order to improve the technological development, and the competitiveness of the country. Therefore and considering the relevance of these networks, there is a necessity of evaluating their development in order to know its innovation potential and performance, but unfortunately the literature about frameworks for assessing these networks is scarce, especially in nanotechnology. The existing ones are fragmented, lineal and non flexible. In general the research in this area is still weak.

In this sense, the main objective of this work is to present the proposal of a framework for evaluating nanotechnology innovation networks. We want to close this gap somehow, trough a systemic, dynamic, flexible and transparent approach. The focus of this framework is related to the evaluation of public innovation networks. The proposal, values the already existing contributions, from which new elements have been added. The framework was validated in three segments of the Brazilian nano-technology network. An empirical research, associated to three assumptions, was developed in order to support the proposal. This research was both qualitative as quantitative and it was used research instruments like an interview to key actors and a survey.

It is hoped that the proposal can be particularly useful for academics, practitioners, and policy makers in order to guide empirical studies in innovation networks and to improve

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their technological strategies and Science & Technology policies. It is also expected that the proposal will be replicated in others sectors and the framework can be also extended to evaluate private networks.

The method was exploratory and depth case study.

Key words. Nanotechnology, innovation networks, public collaborative research

1. Introduction.-

Nanotechnology is regarded as the key technology for the 21st century, affecting almost every aspect of the economy. It has a great potential to stimulate various industries through the advancement of science and technology with relevant impact in the economic and social growth (Herbert, 2006). The race to win market share in this industry of the future is already in full swing.

The nanotechnology modifies the properties of conventional materials, being that in this way it adds value to the products. The technology in the nano-metric scale has infinite possibilities; it is only question of having imagination. The nanotechnology has capacity to add to the products three types of values: of the knowledge, the social life and the businesses, being that the social value is fundamental (Plonski, 2006). In this context, also it is good to understand that to add value to the products with nanotechnology, is necessary that the entrepreneurs take conscience of its multiple possibilities, implying this in a mentality change and a cooperative work between diverse actors.

Without a doubt, and considering that the nanotechnology involves several areas of the knowledge, it needs multidisciplinary teams, and it is essential the partnership of the companies with research centers (Salamanca- Buentello, 2005). Nanotechnology applications influence some areas of knowledge as: treatment of waters, diagnosis of illnesses, agriculture (food processing), environmental health (problems of pollution and new power plants) and manufactures (more productivity and reduction of costs etc. It is expected also to obtain products which are lesser, lighter, and more functional than the current ones, etc.). Another potential benefit is the creation of new tools in order to support the problems of sustainable development. In general its impact will be felt in multiple forms depending on how other technologies converge and if they line up around the nanotechnology. Thus, it is important to mention the increasing convergence of the nanotechnology with the biotechnology (nanobiotechnology), genomic and information technology (Bucher et al., 2003).

Given the promise of the benefits of the nanotechnology, the challenge is in as to develop abilities in order to obtain advantage of its potential (Fyfe, 2006). Many governments consider it, already, as a strategic area of economic development; therefore it is receiving high public investments. Unhappily, and beyond its high potential, many subjects still remain obscure and mainly need bigger research regarding its impacts in the human health, the environmental health and also regarding the effect that it could have, mainly, in the developing countries.

Nanotechnology involves several areas of knowledge (biology, chemistry, physics, computer science etc.), for this reason needs multidisciplinary teams and several actors such as: governments, companies, universities, research institutes, and so on, arising therefore the

innovation networks (Salamanca- Buetello, 2005; Bucher, 2003). Hence, with respect to the innovation networks, also called of last generation of innovation (Rothwell, 1994), they are considered especially in the public sector as critical policy instruments to promote the creation and improvement of robust innovation systems. They are being also considered like learning platforms, constituting themselves in integral element for their competitiveness. Countries like the United States, Japan, Germany and South Korea are currently regarded as the leading nations in nanotechnology, although new countries are emerging to join to this group, for example: China, India and Russia. Latin American's activities in nanotechnology area are increasing and they are being also supported by several mechanisms of public policies. Concerning Brazil, it is one of the developing countries that is deploying innovation national networks in nanotechnology in order to spur the growth of new technologies and increase their competitiveness (MCT, 2006, Nanotec Expo, 2006).

However, and considering the relevance of these networks, there is a necessity of evaluating the development of them in order to know its innovation potential and performance, but unfortunately the literature about frameworks for evaluating these kinds of networks is scarce. The existing ones are fragmented, linear, and non-flexible and they don't consider the collaborative nature of networks. In general the research in this area is still weak. In this sense, the main objective of this paper is to present the results of an ongoing research about the proposal of a framework for evaluating innovation networks in nanotechnology. We want to close that gap existing in the literature somehow, with a systemic, flexible and transparent approach where the collaborative network's nature will be considered. The proposal values the already existing contributions, from which new elements have been added.

We hope that the framework for evaluating the innovation networks can be particularly useful for academics, practitioners, and policy makers in order to guide empirical studies in innovation networks and to improve their technological strategies and Science & technology policies. We also hope that the proposal will be replicated in others sectors.

The paper is organized as follows: in Section 2 we describe the Literature Review the Research empirical method and the proposal of the framework are presented in the Sections 3 and 4, the conclusions and future works are considered in the section 5.

2. Literature Review. –

In this section we have considered an extensive literature review about: a. - Innovation Systems networks and developing countries, b.- Fundaments of nanotechnology and their relationship with networks, and c.- Some relevant models and approaches for evaluating innovation networks, all of this with focus to nanotechnology.

2**.1. Innovation Systems, networks and developing countries**. - Great amount of literature especially related to the process of innovation and the economic development exists since different perspectives: the competitive one, that studies localization in the competitiveness (Porter, 1998); the perspective of the innovation system, and its different levels, like national (Lundvall, 1992, 1994, 2006; Nelson, 1992, 1993; Freeman, 1987, 1991, 1995, Edquist, 1997, Carlsson, 2002, Johnson, Edquist, Lundvall, 2003), sectorial (Malerba, Orsenigo, 1993; Malerba, 1993 2001 ; Malerba, 2004) and regional (local) systems (Cooke, 2001b, Lastres, Cassiolato, Maciel, 2003). This list certainly is not complete even so it allows having an idea about how the innovation has been focused recently.

The last two decades, some alternative approaches have appeared which consider the innovation as a complex process that could not be reduced to the linear model of P&D. Hence, for authors as Lundvall (1999) the innovation is a systemic process because is highly interactive where the feedbacks of the market, as inputs of knowledge of customers, interact with the creation of knowledge and entrepreneurship initiatives. The modern version of Innovation Systems appears in the works of Freeman (1987b) then, these systems are consolidated in the literature in the works of Lundvall (1992, 1998, and 2000) and Nelson (1992).

The use of Innovation Systems as a theoretical framework is increasing in the developed countries. Therefore it is a theoretical structure that can and comes being also applied in developing countries, but with different levels of maturity (Cassiolato, Lastres, Maciel, 2003), Arocena R, Sutz J, 2005, Sbragia et al, 200).

In this research we will base in the National Innovation Systems (NIS) and especially in the role of the networks. Hence, in order to understand in a better way this relationship, we will begin with the definition of the Innovation National System. According Freeman, 1995, Lundvall, 2000, 1998, 1992, it is defined as different institutions whose objective is to create, store, and transfer knowledge and abilities. As a consequence, these institutions influence the direction and speed of the innovation and the diffusion of the knowledge. This set of institutions offers the structure in which the governments formulate policies to influence the process of innovation. In this sense, Lundvall (2000) uses the NIS concept to capture the relationships and interactions between P&D laboratories and technological public research activities from a side and the industry of another side. Hence, the companies do not innovate separately; generally make it in the context of a system of networks of direct or indirect relationships between different actors like companies or organizations, public or private research institutions, innovation and regulatory agencies, etc. considering also, a series of well directed, steady and non bureaucratic public policies. In this sense, the systemic model of innovation, involves innumerable actors who acts according to logics and different priorities and that a surrounding stimulant environment is the catalyses of abilities of each one of the different actors (Sbragia, et al, 2006).

Without a doubt, nowadays there are much interest for improving the quality of the innovation (Miles, Snow, 1992, Cohen, Levinthal, 1989, Rothwell, 1994, Uzzi, 1996, Chesbrough, 2003, 2004, Pavitt, 2003), which takes in account concepts such as innovation systems and construction of competences and interactive learning (Lundvall, 1994). In this context, appear the networks, as a critical element of Innovation systems (Malerba, 2002; Nesta, Mangematin, 2004; Pyka, 1999, 2005, Chiesa, Toletti, 2004). It is considered critical to facilitate the innovative quality and to develop robust systems of innovation (independent of their level, national, sectorial, regional, and local).

In accordance with Villaschi (1992) the developed countries possess mature NIS (United States, France, Japan, the United Kingdom, and Italy) capable of keeping them in the technological border. A second group of countries possess intermediate systems (Sweden, Denmark, Holland, Switzerland, Korea of the South, Taiwan), which are guided basically to the diffusion of the innovation with strong domestic capacity to absorb the advances generated in the mature systems. The developing countries (for example: Brazil, Argentina, Mexico, India, and China) possess incomplete systems, with reduced technological infrastructures. In the case of Brazil, the NIS is considered a system still immature, because deficiencies in several components, since the formation of human resources, infrastructure of

basic technology, until the attitude of its agents (Plonski, 2006). Still thus, it is not the weakness of each component that inhibits the innovation, but the absence of articulations between them and the absence of an innovative environment, all of this in relationship with the attitude of the agents (Anpei, 2004). For Sbragia et al (2006) the developing countries mentioned above have systems of science and technology, and they still have not been transformed into effective innovation systems.

Otherwise and with the aim to understand in a better way the role of the networks in the National Innovation System we would like to define clearly what is an innovation network in our research. For this, we have used as a base the definition of Carayannis (2006), since it includes among other aspects, the systemic perspective for the process of innovation in networks. For this author, the innovation networks are critical instruments of the process of management of the innovation and whose main objective is to promote the technological development supported in the creation, generation and diffusion of knowledge. It uses for this, virtual and physical infrastructures with the aim of promoting the creativity, to extend and to catalyze the invention capacity. Its performance can be in a public or private domain within a perspective of open systems. For this author, the innovation networks are also useful in the formation and growth of the technological entrepreneurship. Thus, in this context, the innovation that intensifies the technological entrepreneurship is visualized as a central element of the innovation systems.

Thus amongst some benefits of the innovation networks we can consider the following ones: they are critical mechanisms for access and exchange of knowledge independent of the physical distance; they are useful for develop and for complement technological capacities as well as facilitating the control or reduction of technological uncertainties; they facilitate the development of new products and services; they gives flexibility and reversibility (the networks are more flexible and are easy to dissolve, allow lower costs, have few commitments and generally little inertia); are relevant mechanisms for motivating collaborative behaviors; etc. (Von Hippel, 1988, 1987; Callon, Laredo, Robeharison,1992; Pyka, 1998; Powell, Koput, Smith Doerr, 1996a; Pyka, Saviotti, 2005; De Bresson, 1991; Carayannis, 2006, Biemans, 1992, Gulati, 1999, Gulati, Nohria, Zaheer, 2000; OECD, 1996, Walker, Kogut, 1997; Ahuja, 2000; Straub et al, 2004).

The role of networks in an Innovation System is key for its normal operation. Hence, nowadays, they has been considered as a critical mechanism for developing robust national innovation systems, as was mentioned above (Lundvall, 1998, 2006) and are being used with intensity as an analysis tool for formulate and analyze public policies of science and technology in different industrial sectors and governments around the world, and as a relevant factor to raise the innovative potential at all levels, constituting in many countries the keystone for their competitive agendas and technological development (OECD, 1999a; Arocena, 2005, Benkler s/d, Stewards, Conway, 2000,). It is important to resilient that networks must be studied in the context of Social network literature (Wasserman, Faust, 1994, Granoveter, 1973, Agapitona, 2003) and the concept of Social Kapital (Rycroft, 2002) because are fundamental in order to promote concepts like trust and collaboration.

Finally, it is a consensus that innovation network will continue to have a high potential in organizations (Nohria, Ecles, 1992) and according with some authors, innovation networks combined with Information and Communications Technologies - ICTs, can be a powerful instrument to management the innovation (Lundvall, 1997, Castells, 2003, Enkel et al., 2004).

The collaborative research and the Public Innovation Network

The collaborative research is considered a key mechanism to produce and disseminate knowledge on science and technology. Its role is to integrate distributed knowledge and skills in new ideas and avenues of research. The necessity for effective flow of inter-organizational knowledge is of particular importance in emerging areas of research such as nanotechnology (Heinze, Kuhlmann, 2008). In the research of public innovation networks (also called of collaborative research at the level of public network), are defined as: instruments of public policy to promote the generation, dissemination and use of innovation, through interactions and synergies between public actors (universities and institutes public) and private. These interactions can be both physical as virtual and formal or informal.

It is expected that all these actions, to help energize and strengthen the Innovation System with a favorable impact on economic and social development (Heinze; Kulhlmann, 2008; Katz, 1997; Geuna, Nesta, 2006). A useful concept to analyze the type of interactions to be developed by scientists within a collaborative action in a network is called network activities. For this research it will be used the network activities concept and types of interactions proposed by Rijnsoever, et al (2008). For this author, network activities are the ways in which the researchers use their contacts for purposes of research. These contacts can be of different types, ranging from formal to informal, follows these types of interactions:

• Internal Networks, including only contacts within the faculty;
• University Network, including contacts only within the university;
• External networks, including contacts with researchers working in other universities; networking with Industry, including contacts with firms.

In each of these interactions the nature and interdisciplinary vary. The relationship with a firm may include since a collaborative research, until financial aid. Thence, the company can finance the search, the company may be a spin-off of the university, and so on (Rijnsoever et al., 2008). Several initiatives have been developed to strengthen these networks from the perspective of public policies for innovation in different countries both developed as underdeveloped with aim to integrate into networks to researchers working in isolation, so that they can interact in a more articulate way with others researchers irrespective of geographical distances, all of this, to exploit the innovation resources in a best way. One example of this situation are the Excellence Networks, which are already mature forms of collaborative work in network (Katz, Martin, 1997).

Several public policies initiatives have also been developed to promote and strengthen through these collaborative actions the interactions between science ad technologies. The idea is that the generated knowledge becomes technology with favorable impact in the economy and society. Thence, policy instruments have been developed, such as: legal systems, metrology systems, incentives to private enterprise, public funds for research, promotion to the training of human resources, training in the development of venture capital and so on. All of these initiatives has had the aim of creating and strengthen an environment of innovation, entrepreneurship and skills to work in networks. Some countries have achieved better results with respect to others such policies, but without doubt, this also depends on the own technology path and innovation culture of each country.

2. 2. Nanotechnology and networks. - Nanotechnology is a field of research and innovation related to the construction of devices, generally materials and systems in the scale of atoms and molecules. One nanometer is equivalent to one billionesim part of a meter. The

diameter of a human hair measures 80,000 nanometers. In such scales, the usual rules of the physics and chemistry do not apply more. For example, characteristics of materials such as its color, conductivity, reactivity, can vary substantially between the nano and the macro scales. There are some definitions of the nanotechnology, and considering our research we have included the defined by Durán and de Azevedo (2002):

> *The nanotechnology is the creation of functional materials, devices and systems through the control of the substance in the scale of nanometers, implying in systems that present new phenomena and properties, that are dependents of the size, as the super plasticity due to high superficial area of these particles".*

The nanotechnology modifies the properties of conventional materials, being that with this it adds value to the products. The nanotechnology in the nano-metric scale has infinite possibilities, is question of having imagination. The nanotechnology has capacity to add to the products three types of values: the knowledge, the social life and the businesses, being that the social value is critical (Plonski, 2006). In this context, also it is good to have in mind that to add value to the products with nanotechnology, is necessary that the entrepreneurs take conscience of its multiple possibilities, implying this in a mentality change and a cooperative work between diverse actors.

Without a doubt, and considering that the nanotechnology involves several areas of the knowledge, it needs multidisciplinarity, where several actors work in a systemic way (Salamanca-Buentello, 2005, Bucher, 2003, Meyer, 2006). Thence Nanotechnology need networks in order develop their innovation activities. According Rothwell, 1994, Saviotti, 2000, Forfás, 2004, Rycroft 2002, Steward, Conway, 2000, the Innovation networks are considered as critical policy instruments to promote the creation and improvement of robust innovation systems.

Otherwise, the nanotechnology has impact in several areas of knowledge, as: treatment of water, diagnosis of illnesses, monitoring of health trough sensors, agriculture (food processing), environmental health (problems of pollution, new power plants) and industry in general (more productivity, reduction of costs, it is also expected that the products with nanotechnology insertion are lesser, lighter, more functional, than the usual ones, etc.). It is also expected that the nanotechnology can contribute with new tools with which we can guide the problems of sustainable development and we can improve the available technologies and also become them more efficient. In general its impact will be felt in multiple ways depending on the convergence of other technologies (Miyakasi, Islam, 2007. Thus, according Bucher et al. (2003) it is important also to mention the increasing convergence of the nanotechnology with the biotechnology (nanobiotechnology), genomic and information technology (the Nan biotechnology will be developed in the Section 5). Given the promise of the benefits of the nanotechnology, the challenge is in developing abilities to improve its potential (Fyfe, 2006). Many governments consider it as a strategic and promotional area of economic development and, therefore it is receiving high public investments. In the view of Herbert (2006), if the objective is to add value to the economic sector of a country, the financing for the nanotechnology must be high in order to attend the several demands of the several actors.

Otherwise, the nanotechnology is being configured as a global phenomenon. Its advances are more accepted in developed countries, but there are some significant activities in the developing countries (Meyer, 2006). For Hebert (2006), four stages exist in which the nanotechnology area is characterized: a**.** financing, because it requires mainly heavy public investments; b**.** scientific development, it is related to the knowledge capable of generating new products and services, which have the origin in the universities and research centers, c**.** manufacture, it means manufacturing in large scale, d**.** commercialization, this is the capacity that innovations arrives to the market.

In the developed countries, only the United States and Japan dominate the above four stages (Herbert, 2006). Although, the knowledge is not more concentrated only in these two countries, since the capacity of research and innovation in nanotechnologhy is spreading out around the world, specially in Europe and Asia (Meyer, 2005, Lambkin, 2005). In Europe, the case of Germany, France and the United Kingdom deserves prominence, since the innovation has been the base of its prosperity. In the case of Germany, one of the most important initiatives is the Excellence network of Kompetenznetze, which is a critical instrument to become internationally known and it is the best network of competences in Germany, since it is a platform of communication and information used to look for partnership. In the case of France, they value the innovation networks, and are highly innovative. They have capacity to commercialize its innovations easily, even so with scarce public financing in nanotechnology. Concerning to the United Kingdom, they are also highly innovative, with excellent policies of financing, even with problems to commercialize the innovations in nanotechnology.

In Asia, beyond Japan, the developing countries that are leading in nanotechnology are China, South Korea and India. In the developing countries, the nanotechnology is an increasing phenomenon and it is considered relevant because improves the productivity (Salamanca- Buetello et al, 2005). In these countries the nanotechnology has several applications, for example, in the health (offering diagnosis tools, surgical systems of delivery drugs, vaccines, devices, monitoring of the health state using sensory which can help to detect presence of micro-bacteria, etc.), in agriculture (diminishing infantile mortality, in part for developing the fertility of the ground and raising its productivity), in the manufacture (raising the productivity of the processes), etc. In general, the solutions of nanotechnology in developing countries will depend on costs, supply and easiness of use (Millennium Report, 2005).

Latin American's activities in nanotechnology area, are also increasing and they are being supported by several mechanisms of public policies (Salamanca- Buetello et al, 2005), Concerning Brazil, it is considered in the intermediate level of development and it is among the developing countries in the world that is deploying innovation national networks in nanotechnology in hope to spur the growth of new technology (MCT, 2006, Durán, 2006, Nanotech Expo, 2006, Toma, 2006). The government in its National Plan of Science and technology stresses the need for improving its National Innovation System and as a critical instrument of this, the development of their innovation networks to promote technopreneurship in the country.

Unhappily, and beyond its high potential, many subjects still remain obscure and mainly need bigger research regarding its impacts in the human health, the environmental health and also regarding the effect that could have mainly in the developing countries. Given the

promise of the nanotechnology benefits, the challenge is in the development of abilities to use advantages from its potential (Fyfe, 2006). Many governments consider nanotechnology as a strategic and promotional area of economic development and therefore it is receiving high public investments and also going beyond networks, then they are forming clusters of nanotechnology (like the French case).

2.3 Evaluating networks and nanotechnology

Network evaluation is a growing area of research and writing, thence In this section we presents a brief overview of selected literature concerning the evaluating of networks in the context of innovation systems with particular attention to nanotechnology. Considering that the literature in evaluation networks and especially in nanotechnology is scarce, we have looked for in related knowledge areas with the aim of obtain elements to configure the current proposal.

Why is evaluation important for networks?

The evaluation of networks is important for different reasons:

- Evaluation turns essential the learning process and it must be related with success and failure more than as mechanisms of control (VINNOVA, 2006);
- It is also important because it has an accountability contributions, because is based in indicators of effectiveness and efficiency;
- The process of evaluating networks is also relevant for planning and strategizing; because it helps to measures progress and propose solutions to problems, consolidation and sustainability of networks. Otherwise, for a network to be sustainable, it must continue to be relevant to its members and to its context. This requires that a network to be adaptable. Some networks have difficulties changing focus, processes or membership. Strategies for developing flexibility include using evaluation process, having a fairly broad thematic focus and building structures that allow for flexibility. Otherwise because networks are faced with rapidly changing social, political and economic situations at the global and local levels, they may have to change their structures to meet changing needs. The generally light structures of networks can facilitate this flexibility. The capacity to evaluate the ways the network is carrying out its work and how these can be improved also enables networks to adopt appropriate structures and adapt them to meet changing needs (Karl, 1999),
- Trough evaluation is possible to have a status of the network development and inclusively parameters of comparison respect to others networks.

Church et al, (2003), recommend that evaluative processes be incorporated into the routine n of network operation. They suggest that as a necessary part of their flexible and evolving nature, networks are continuously undergoing tacit evaluations and there is a need to make this process explicit in a dynamic, organic and linked work. In this sense Karl (1999) outlines the complexities for practitioners in monitoring and evaluating networks.

The different analyzed areas concerning to the evaluation issue were:

a. Managerial mechanisms for evaluating the performance of firms. - Mainly Kaplan and Norton (1992) model is revised. These authors developed the Balanced Scorecard-BSC as a tool for evaluating the performance of firms using financial and not financial indicators. The restriction is that the BSC is formatted for individual organizations with its own data and it isn't adequate for networks.

b. Models for management innovation. – Here, the focus was for models that consider the process of evaluation. The works analyzed were Rothwell, 1994, Patel and Pavit, 1995)

c. Frameworks for evaluating innovation systems. – it was considered some previous works like Bartholomew (1,997). The proposal of performance of Innovation Systems (Gregersen, Johnson, 2005) based in the capability concept and measures was analyzed. It is important to resilient that this last approach and the indicators are extremely relevant and offers a different point of view different to the classic indicator.

d. Frameworks for management and evaluating innovation networks. - Biemans, (1992), Bucher, 2003, Callon, Laredo, Robeharison, 1992, Germunden, 1995, Malerba, 2002, Harland et al., 2004, Bullinger, 2004, Luggen et al., 2005, Parks H, Jeffery R, 2006. These models considers the evaluation process but in a fragmented way. It was also found general frameworks for evaluating networks in several areas like health, education and son on, always in a fragmented way (Church, 2003; Karl, 1999).

It was also paid special focus in some approaches in nanotechnology (Meyer, 2006, Herbert, 2006) and in areas related to nanotechnology like biotechnology (Guedes, 2000, Mariscano, 2005, Ahrweiler, 2001), Bio-pharmaceutical sector (Guarau, 2005). Bellow, we present a brief review of some relevant aspects of the above literature.

It was found that are different elements of network performance considered by several authors (Callon, Laredo, Robeharison, 1992, Bartholomew, 1997, Straub, Rain, Klein, 2004 and Bullinger, 2004, Luggen et al., 2005, Karl, 1999, Ahrweiler, 2001, Church et al, 2003, Meyer, 2006, Herbert, 2006). But in general there are some common considerations in evaluating networks like these:

- Measuring intangible aspects. - aspects like building relationships, enabling new learning, adding value, influence of interaction and cross-fertilization are important in the intentions of supporting networks and can be challenging to articulate and document for evaluative purposes (Karl, 1999).
- Issues of attribution. - as with all project modalities, measuring and claiming credit for results or change is problematic as it is impossible to realistically segregate the contributions of projects inputs and activities from their surrounding context. It is increasing in a network due to their often far-reaching and multi-stakeholder membership structure and due the often political and global nature of networks (Karl, 1999, Church et al, 2003). In general the challenge of attribution in networks is an issued of trust (Karl, 1999) and it must be focused on network performance rather than searching for impact.
- Looking at internal and external achievements. - In any network evaluation process, it is important to look at the networking processes occurring between and among the members (Church, 2003). It is considered that it is of fundamental importance for a network to identify and comprehend its internal processes and external achievement. (At the level of influencing activities).

Otherwise, some authors present the necessity of measurement of networking and tools for evaluating networks. However, there are specially more focus in research about tools for network (instead of network evaluation measures) which are developed from different point of view and supported in components from various methodologies, including SWOT analysis, Result Based Management, Logical Framework Analysis, Outcome mapping, appreciative inquiry and evaluation methods from the Human resources field and so on

(Church, 2003). It is also considered that Networks require unique planning, monitoring and evaluation methods that are tailored to their structure and functioning.

Literature comments

The networks of innovation are central to the process of invention, innovation and it is expected to promote the collective knowledge and expertise of its members. Evaluate performance of networks and a specific form of innovation networks, as well as managerial mechanisms for support is still an issue neglected in the literature, with few exceptions (Enkel; Gassmann, 2005; Provan; Milward, 2001, Church, 2002). The same is true for networks of nanotechnology. The few existing work for networks in general have preferred the ex-post (based on past results of the network), and are based in a fragmented approach without systemic view of its components. In spite of this picture, it is currently a growing interest in this subject and in the definition of models to assess results of networks and also for developing models that monitor the creation of value networks in real time (ENKEL; GASSMANN, 2005), as well as definition of metrics of innovation. Unfortunately and in general, prevailing traditional metrics of entry and exit, and not metrics related to the innovation process in networks. Some exception to this statement is the work of Rycroft, 2004, Gregersen, Johnson (2004).

There is also need to develop proposals to assess the networks of innovation, from a perspective of factors called "hard" and "soft", that is both in quantity as quality, comprehensive and dynamic character (which may go beyond traditional assessments of entries and exits), considering also the process of innovation in network, and within a systemic approach, multidimensional considering mechanisms for evaluating performance not only of past results (ex post), but the results in real time (during) and why not, ex-ante (as Foresight networks). All this with the purpose of responding to the dynamics of innovation in the context of the current economy or the knowledge economy of learning (Lundvall, 1992; Gersen; Johnson, 2004).

In addition to all this is desirable that evaluation and its metrics can be used for purposes of comparison, and mainly as a mechanism for learning, not as a mechanism of punishment. So even as other authors have recommended the evaluation process of networks should be incorporated into the routine of networks and go with the challenge of creating a culture of evaluation (Church et al, 2003, Legrand, 2006). It was also founded in the literature that the metrics have evolved over several stages and that today we already have proposals for a fourth generation of indicators, it means indicators for networks (that reflect the dynamics of the process of innovation) in addition to the traditional and ENTRY EXIT, existing. Meanwhile, the research is still in its infancy. Moreover, is also necessary that any proposal of factors and contemporary performance metrics can be part of a theoretical model, or of an agenda for research or to meet public policy goals (Gregersen and Johnson, 2004), and considering that the proposal of model for evaluation and metrics can not be universal, but adjusted to the characteristics of each scientific field (Coccia, 2005).

Currently there is still little empirical research about evidence on factors that affect the performance of networks for innovation. However, with regard to progress in research on instruments to support management to evaluate the innovation and its dynamics, it was found some relevant tools and some of them supported in bibliometric analysis, analysis of patents, in software or in technical and social networks.

This research attempts to contribute in a modest way to overcome this gap in the literature

specially in the nanotechnology field, with the proposal of a model to assess their innovation networks, and its is open to dialogue and contributions to enable it to be improved. From the literature, it is possible to have a vision of the initial framework, but always considering that assessing networks is a complex process that includes many dimensions, factors and indicators, especially when it is pretended to evaluate them in a systemic approach. Follows a preliminary proposal and their dimensions:

• Environmental Network Dimension: includes all those factors that are entrances to the network and affect their performance;

• Network innovation process: it is one of the contributions of this work, because attempts to assess the black box of innovation in network and it is a point of beginning to understand the management of networks.

• Technology Transfer dimension: includes all those factors related to the innovations generated by networking like knowledge transformed in technologies, with the aim to reach the market.

Other aspects of the innovation process such as production, distribution, analysis of demand, are not considered in this framework, because this research is focused on the public innovation networks

As consequence of this literature review, it has been considered the following assumption:
Assumption 1. The environment of the network and their factors affect the network performance.
Assumption 2. The processes of the network and their factors affect the network performance.
Assumption 3. The process of technology transfer and their factors affect the network performance.

In general, our interest was to understand better, process and mechanisms of evaluation. Based on these approaches we obtained critical elements to configure our proposal.

3. The empirical research

3.1 Type Research

The research was developed in two phases and in each stage the kind of study and instruments to search for data collection have changed, see below:

First phase of the research. - This phase was exploratory (Vergara 2004). It held exploratory because it is in the area of nanotechnology with little knowledge and respect for the systematic management of innovation networks and in particular the process of evaluation of performance. The exploratory research, according Yin (2006) Vergara (2004) and Einsenhardt (2007) is qualitative and of case study. In this exploratory phase was developed a literature review and a documental study (through the analysis of public documents of nanotechnology innovation networks, such as, reports, official documents, empirical evidence, etc. aailable on the web).

As a result of this phase it was obtained the initial proposal of a conceptual model to evaluate the performance of innovation nanotechnology networks, which considers the most

critical factors to be considered in its evaluation (see section 3 Proposal of the Model). In this first phase were applied 6 semi-structured interviews with experts of Nanotechnology, which had the purpose of improving the first version of the conceptual model.

Second phase, the empirical study. -The research in this stage was the case study (Yin, 2006 and Einsenhardt, 2007) and had intended to obtain information and perceptions among the key actors of the Brazilian nanotechnology network, about the critical factors that affect the performance of the network. As the Brazilian network has several segments distributed in the national territory, it was considered only three of the 10 current segments of the network (see more in front). According Gassman and Enkel, s / d; Einsenhardt, 2007), the case study has the following characteristics: a) Is holistic, because it has the purpose of seeing the problem as a cohesive whole; b) It may be only a case or multiple cases (the ideal is that the study is based on at least two cases, which should be inclusive in their contrasting results, to make the evidence stronger), and c) it can use qualitative and quantitative data.

Use of qualitative and quantitative data. – As it was mentioned above, this kind of research can use both qualitative as quantitative data. With this step aims to show three alleged consequence already indicated earlier as the literature review. These assumptions are based on the dimensions identified as critical to evaluate the performance of an optical network from the public: The environment of the network, the processes of the network, and technology transfer. Each of these dimensions has associated factors that formed the model for evaluation.

For this research the performance of the network means that the network reaches results in terms of efficiency and effectiveness during the process of innovation and also after a specified period. This performance can be measured by indicators of tangible and intangible aspects inherent to the network nature.

Research Plan of the case study (Yin, 2005.

In the case study, the unit of analysis is the case. In such a situation were chosen three segments of the Brazilian nanotechnology network therefore it was obtained three units of analysis, basically, the segment of nanobiotechnology, nanocosmetics and RENAMI Network

Selection of subjects.-The subjects who provided the data were the key actors of the network in its various levels: coordinators, sub-coordinators of the network, researchers "seniors," researchers "juniors" (graduate and post-graduate students), representatives of the government (Ministry of Science and Technology), representatives of R & D network of partner companies, managers of spin-off formed from the networks, among others. It was also considered the participation of Brazilian nanotechnology experts.

Data Collection.-The proposed model was developed in the first phase of the research and was used both primary and secondary sources. Secondary sources were bibliographic (obtained in books, journal articles and scientific journals, conference proceedings, scientific papers, theses, dissertations, research on web sites, etc.). Documentary sources were obtained through public reports of the Brazilian government and other entities with respect the network of nanotechnology, etc. The primary sources were obtained through semi-structured interviews applied to 6 Brazilian experts in nanotechnology.

In the second phase of research, which belongs to the validation of the proposal, the data came from secondary and primary sources:

Secondary sources were obtained from public reports available on the web or in the workshops of governmental entities, in newspaper articles, scientific papers published in public databases and on information obtained through participation in conferences and technology related to the Brazilian Industry Innovation, innovation and nanotechnology developed during 2007 and 2008 in Brazil, and abroad (in Europe, like Portugal and Russia).

The primary sources came from applications of the following research instruments: Questionnaires and interviews.

The questionnaire.- The development of the questionnaire was based on the recommendations made by Günter(2003) and it was developed in accordance with the preliminary conceptual model for assessing the performance of innovation nanotechnology networks. It had questions about: • Information on the profile of the interviewee; • Questions about the different dimensions of the proposal based in Linker scales with 5 options (with the options: total disagreement, disagreement, indifferent, I agree, I agree totally), considering these options besides the "know", because according Günther (2003), when there is the option of not having able answer a question, you should leave the alternative "I do not know" explicit. It was also consulted about the importance and status of the factors in the networks.

For the purposes of the questionnaire validation, it was developed a first pre-test with some experts in the subject. Otherwise, the original intention was to apply the questionnaire virtually, that is, the players could complete the questionnaire using the web. It was little participation of actors, then it was decided that the application of the questionnaire would be carried out face to face in selected centers. The centers visited were: the State University of Campinas (UNICAMP): Institute of Chemistry, Federal University of Rio Grande do Sul (UFRGS): Department of Chemistry, Institute for Technological Research of the State of Sao Paulo (IPT), Secretariat National Nanotechnology in Brasilia, Department of Physics and the Institute of Chemistry of USP. In total were completed 30 questionnaires by coordinators network, researchers, PhD students. The work of collecting data was not higher because of difficulties of time and budget.

Interview Guide .-The interview face to face was developed to support the qualitative research. This interview took up to three hours each and was applied in the different networks with focus to the key actors, such as Porto Alegre, Brasilia and the State of Sao Paulo (city of Campinas and Sao Paulo).

The period of data collection was from April 2007 to June 2008 in an intermittent way and according to the availability of the interviewees.

Limitations of the method. - According to financial and time restrictions, the research does not consider all the Brazilian network of nanotechnology and specifically, it focuses in three segments of the networks. We remark that another limitation is the fact of the case study does not allow generalizations, however the intention is to validate the framework in other networks, with the aim of improve our framework.

3. Analysis of data.-
The data analysis was done in a qualitative and quantitative way.
3.**1 Qualitative analysis of the data.**
This type of analysis has been developed both in the first stage of exploratory research as in the case studies. This analysis is already enriching to take a broader view of the problem to be searched, and facilitates to capture perceptions of the interviewees. In this type of evaluation could be used assumptions, which do not involve testing, only confirmation or not, through mechanisms including non-statistical (Vergara, 2004). It has been combined two criteria (Vergara, 2004) the description one and the interpretative one. To facilitate the analyses of the data, the data was first tagged with the aim of presenting them in a structured way. The data was treated in an interpretative way and was also established standards, and in general was made an effort to relate the data obtained in interviews with the literature, empirical evidence and existing documents. From this analysis it was possible to obtain information which enabled improve the first version of the model for assessing the performance of nanotechnology innovation networks.

Dimensions of analysis and questions From the analysis of literature are prepared an initial proposal for the evaluation of nanotechnology innovation network, which considered several dimensions of analyses:

I) Environmental Network Dimension (National Environment of innovation-related to the National Innovation System-SIN): The focus is in the politic dimension (based in the government intervention) such as: the Public policies for nanotechnology innovation and their respective instruments, in the strategic national network. The international environment is also considered; II) The Innovation Network Process: it is concerned to the collaboration process specially the interaction between actors such as, public research and firms; III) Technology Transfer in Network: it is related to the different mechanisms used for transfer knowledge in technology in order to obtain richness with impact in the economy and society; IV) Manufacture in scale and Commercialization; V) Demand (specially isues of environmental and health security).

The results included to 25 actors, among coordinators, researchers and post graduated students and in order to make a qualitative assessment, the questions were classified by the size mentioned above. For details of this analysis see Escalante (2008).

3.2 Quantitative Analysis of data Measuring the performance of networks of Nanotechnology is a task of exploratory character, researches in this direction are few in the international literature. The proposal of this work is to provide a model that effectively measure the performance of the network of Nanotechnology in Brazil is indeed unprecedented. The models that attempt to explain performance or conduct (latent variables) establishing relationships with private performances are called models of beliefs (Brevidelli. Ciancarullo, 2001, p.196) and are widely used in various areas of knowledge.

According to this model, the performance of a network depends on several factors including: First: the environment surrounding the network, which is the set of variables that allow a network carries and obey their function efficiently. We can consider this case variables such as strategic national ("there are plans on the future of the area at the national level?" Any strategy? "), Policies for innovation in nanotechnology in the context of the SIN which are associated with the availability of funds (" are they sufficient? "), infrastructure (such as laboratories," are able to work? "), human resources (" the people who work in the network,

is qualified? "), legal milestones, and so on. Secondly, the Dynamicity of the Network, this is the quality of the interactions between members of the network, we take this case to variables such as structural density ("there are many actors?"), The intensity (the actors have contact between them? "With how often they talk? ") and governance (" the coordinators of the projects are fulfilling their duties? "there is interaction between coordinators of different projects?" as are the mechanisms of coordination? "). Thirdly, the impact of the network, where the most important variables to be taken into account are the number of projects in basic research ("suffice?"), The quantity of patents, the number of projects in partnership with industry (which the current state? ") and venture capital.

Still, according to the model of beliefs, we are considering the hypothesis that the performance of the network depends on a number of factors, which in turn are determined by sets of talents variables. But we have yet to answer the question of what represents the model for their own performance, that is, what level? The scale of measurement is the type ordinal ". We believe performance as a performance measure that contains the following variables that a greater or lesser importance in the evaluation of the actors (developers of search): scientific publications, patents applied for patents licensed, Spin-Offs, collaborative projects and the number of trained staff.

Method:
The study was carried out in different parts of the network in Brazil, such as: Campinas (UNICAMP), Sao Paulo (USP), Belo Horizonte (UFMG), Brasilia (MCT) and Porto Alegre (UFRGS).

Table 1 - Profile of the sample

Rede	**N**	**Porcentagem**
Nanocosméticos UNICAMP	6	20
Nanocosméticos UFRGS	2	6,67
IPT – Nanocosméticos	2	6,67
Nanobiotecnologia e Sistemas Nanoestruturados	8	30
Nanobiotecnologia e Sistemas Nanoestruturados UFRGS	2	6,67
MCT – Coordenacao Nac. De Nanotecnologia	2	6,67
Instituto do Milênio	2	6,67
Nanotubos de carbono	1	3,33
Rede Nanotec – USP	1	3,33
RENAMI	4	13,33
Total	30	100

The construct under review was the network performance, and the population under study was limited by all the actors that integrate the different networks of nanotechnology in Brazil. The sample was not random and built by people (30 actors) who agreed to participate in the study and answering spontaneously to the questionnaire. Among them, 33.33% belong to the network of nanocosmetics, 33.33% to the network of Nanobiotechnology and nanostructures systems, 13.33% to 20% and RENAMI network to other networks. The profile of the sample can be seen in Table 1. These same data divided into broad areas are described in Table 2.

Table 2 Division in large areas

Rede	N	Porcentagem
Nanocosméticos	10	33,33
Nanobiotecnologia e Sistemas Nanoestruturados	10	33,33
RENAMI	4	13,33
Outros	6	20
Total	30	100.00

.

These tables show the relative uniformity of all participants of the survey when considering the areas of focus within the environment of innovation networks. The data collection for quantitative analysis was done using the questionnaire described above. Following the collection of data, the scales have undergone trial of specialists (a statistical and a Computer Scientist). The analysis of reliability was made to determine the accuracy of the scales used, this validation is also made to determine the degree of adequacy of scales with the construct, and both were used for the coefficients of Cronbach Alpha (Bredivedelli; Ciancarullo, 2001, p. 195), which determine the internal consistency of the statements. To do the analysis were worked mainly the questions of Part 2 of the questionnaire, formed by 33 questions. These questions were grouped so that the groups had a high correlation measured by the Cronbach's Alpha. The Cronbach's Alpha, also show the consistency within each group. This analysis was developed using Minitab ® Version 15.1.1.0. The classification that best fit was linked to the dimensions of the model (external environment - size 1, and management, dynamics and structure of the network - size 2) and the character of the questions that could be of importance or diagnosis of the factors (model). Forming well four major groups: B. Group 1. Dimension 1 and diagnosis. Group 2 size 2 and diagnosis. D. Group 3: 1 and Dimension model. E. Group 4: Size 2 and model. For details of quantitative analysis, see Escalante (2008)

Discussion

Some years have passed since the implementation of these national networks in both developed and developing countries, such as Brazil and increasingly has emerged the necessity to be aware of the achievements of its innovative potential. Also there is a necessity for mechanisms to monitor the development of these networks. However research in this issue is scarce in the literature, thence tools to support management have also been poorly developed, such as the evaluation of these networks. They are exception like the works of Luggenn, 2005; Bullinger et al, 2004 and Elken, Gasmann, 2005 In the case of nanotechnology, this type of work are even more scarce and an exception is the work of (Heizen, 2008). However, all these works have a fragmented view of the process and not systemic. Given this background, and with a desire to contribute in a modest way to fill the gap in the literature, it will be developed a conceptual model for assessing networks of innovation in nanotechnology. Therefore, as part of empirical research (supported in qualitative and quantitative study) it was tested the proposal and their critical factors. This process was developed with the key actors of three segments of Brazilian nanotechnology network (nanobiotechnology, RENAMI and Nanocosmétics).

Among the factors considered relevant to assessing a network of innovation of nanotechnology, from the perspective public and in the context of innovation system, the results of qualitative and quantitative analysis, show that the respondents confirmed the factors considered in the initial proposal of the model built from the literature. So we can

consider that the model defined initially was confirmed. But the importance of some aspects has changed

Strategic innovation network orientation. –It was a consensus among respondents that the National Strategy and the strategy of each network, both properly aligned should be the basis of the evaluation process. This is independent if the network has not a long-term orientation. The strategic direction of the network means that networks should be based on prospects for the future of innovation in the long term (Bullinger et al, 2004; Escalante et al, 2007) both at the national level (which are already public networks) as the level of each network which is expected can be aligned with the strategies at national level. According to Kaplan and Norton, (2000), the strategies are the only means by which organizations create value. Since the creation of value of networks is not only concerning the tangible assets, but also intangible.

The strategic perspective on the networks to develop a common vision and have their own culture network, allows the network to focus on specifics goals appearing the strategies of innovation in networks long term. Strategic decisions in innovation implemented in the selection of fields of innovation, defining the characteristics and unique proposals, the sources of expertise and so on. Additionally, the strategy of innovation has to take stock also in the port folio of activities, for example, on the degree of change (radical, incremental), length of duration of projects of innovation (the long or short term), risk (high or low), etc.. (Bullinger, 2004). Meanwhile, the quality of the strategies depends on its implementation, so we need to have mechanisms to monitor its operation and results. However, as mentioned above there is lack of management support tools, for example, those that support the process of evaluation of networks.

Public Policy. This factor is considered essential to public networks, since the public policy of innovation, seek to strengthen the environment for innovation through its various instruments and regulations. To promote through its activities the creation of instruments and regulations and economic and social development from innovation in networks in nanotechnology, in this case public. This factor was also included the cultural dimensions that affect the process of innovation in network (Ahrweiler, 2003).

Education and training of Human Resources .- it considers a critical mass of human talent with high qualifications to be absorbed by industry or academia

Infra-structure.- it is related to have world-class laboratories for research. It also considered virtual environments for innovation in networks. Legal mechanisms and certification systems ? Promotion of Capital venture for example (forrmation of spin-offs).

Network skills. This factor was also considered critical for success of networks. Meanwhile, networks members need to be adapted in order to develop capabilities and competence. (Bullinger et al, 2004; Ahrweiler, 2003) Follows some competencies for partners • Selecting correctly the partners; to absorb and integrate information; integrate different types of knowledge; in the network to solve several problems, and so on.

Generation of knowledge and technologies.- it means to generate technologies and processes from basic research and given a strong and vital partnership with the performance.

Technology transfer in network. – It is concerned to research-oriented or growth through sustainable innovation in network (Bullinger et al, 2004). This means manufacturing in scale and subsequently commercialized by industry.

Networks Governance. - It is related to the administrative structure and mechanisms of support, for instance, internal politics, internal mechanisms of communications, mechanisms of control etc. The network governance process must be aligned to the strategic orientation. As Professor Galembeck (2008) spoke: "{...} If an organization has good mechanism of governance but unfortunately this process is not aligned to the national strategic orientation of the network, it doesn't have relevance. The main idea in this point is governance aligned with strategic orientation. The idea is to confirm a mix model of evaluation.

4.-Towards a Framework for Evaluating Innovation Networks

In this section we present the advances of an ongoing research about the proposal to evaluate the performance of networks of innovation in nanotechnology. The proposal has the following characteristics and dimensions:

4.1 Characteristic. - The characteristics of the proposal are:

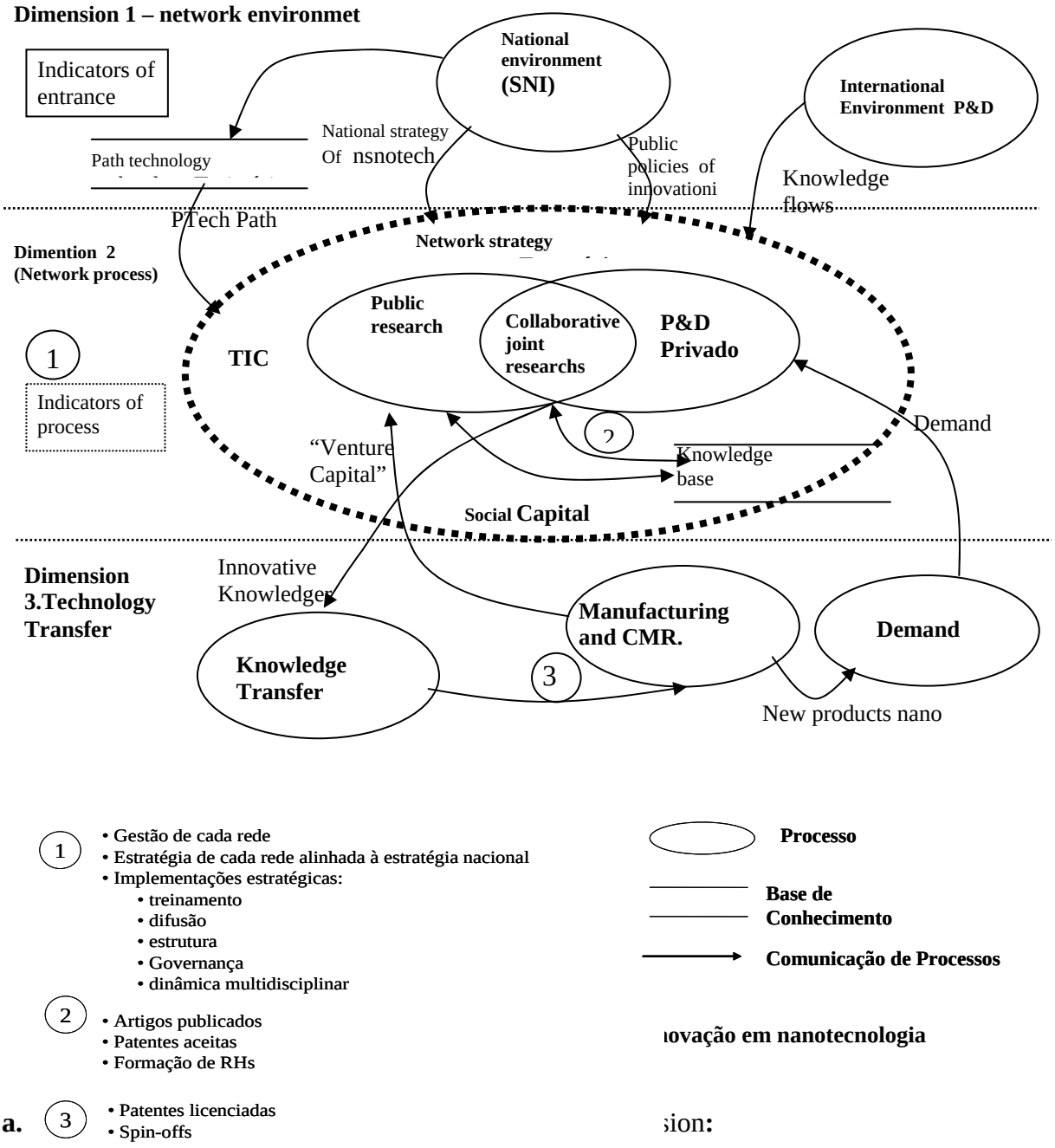
- **Systemic Approach**. - This proposal is an attempt of development of a systemic approach of innovation networks evaluation. - The dimensions are studied so much in the context of Systems of Innovation, inasmuch as the innovation networks are considered instruments key to fortify and to strengthen systems of innovation (Freeman, 1997, Lundvall, 1992, 1998, 2000, Nelson, 1992,1993). The dimensions must be interconnected in a variety of forms, prevailing a systemic approach of these, since it is not the sum of the parts that plows important but the relationship between these parts. Evaluation that examines the relationship between the network and the different dimensions and actors would go Officers' Club of Revol.
- **Flexible and transparent**. - Proposal looks for to be flexible (it can support to changes in the dimensions, factors, indicators agreed to the changes which they can appear in the environment) and is transparent (engaged in a dialog with the actors it nails).
- **Quantitative and qualitative Aspects**. - Both dimensions are important, nevertheless in a network approach, those of qualitative nature are critical because the character of synergy and collaboration between the network actors (Wasserman, Faust, 1994)...
- **Internal and external Aspects**. - The dimensions include internal and external aspects of the network. In the spirit of networks, these levels plows not hierarchical but provide separate categories to enhance our understanding.
- **Strategic Direction and alignment.** – The aim is to make relationship between the dimensions of analysis with the strategic orientation of the network. Will at any moment be tried to interrelate the dimensions of analysis with the strategic direction of the network. In a second stage indicators are being developed. These indicators must be aligned with the macro objectives of the network.
- **Value existing contributions**. – Based on the existing contributions have been added, adapted new components in order to enrich our proposal according to the

characteristics of the nanotechnology area.

4.2.- Dimensions - An approach to evaluate networks includes several levels of analysis, considering their complexity and their different dimensions. Thus the effort has been made for to identify from Literature and empirical research the dimensions to evaluate networks (without a doubt these dimensions are not complete). In this sense 5 dimensions have been identified critics or levels of analysis (see Fig. No 1).

1.- National environment.-Interventions and incentives of the Government (National, Regional). This dimension talks about the different activities from the government to promote the development of the nanotechnology, supported mainly in public policies and instruments to operate them. Thus, the direction strategic in nanotechnology and the different mechanisms from Public Policy are analyzed for example to develop this area. Aspects like the existence of a Public Policy for Nanotechnology are analyzed for example, of a National Strategy, National Programs like of infrastructure (legal, for the Intellectual Property, of formation of Human Resources (scholarships, international mobility etc), public financing, alliances, programs of diffusion, programs for use and acquisition of Technologies of Information and Communication for the innovation, of intensification of venture capital etc). All this with the purpose of evaluating the promotion of an innovation atmosphere to support the nanoscience and nanotechnology like competitiveness factor and development. It is emphasized that this dimension and analyzed taking into account the technological trajectory from the country. The key actors are the government (in its different levels, national, sect oral, regional, local) and the different representatives from their institutions here that promote the innovation (regulatory agencies of innovation, agencies, agencies of financing, etc).

Figure 1- The proposal



2. |Innovation Process in networking. - This size to examine the innovative potential of the network associated with the various activities to generate knowledge (tacit and codified) and technologies to network (Polany, 1967). If also examine the modalities to generate knowledge and technologies as: provision of portafólio of expertise, joint projects with local industries and with international bodies, etc. This dimension of analysis to consider the assessment, in an integrated manner, the three components of a network: the structure, dynamics or content and governance (Provan; Milward, 2001). It also includes elements of Callon et al (1992), especially considering the size of knowledge and technology of the network (called by the authors of scientific and technological center, respectively) and characteristics of network (convergent, diffuse, small or large, etc.) . Finally, some aspects of social networks will be taken into account, mainly to assess how dynamic aspects of the

structure and configuration of the network (Agapitona, 2003; Granovetter, 1973). Undoubtedly, the concept of social capital will be also taken into account (Rycroft, 1993, Wasserman, Faust, 1994). In this analysis the strategic direction of the network will also be emphasized.

A critical aspect in this process is the interaction between actors (within the same institution, between public institutions and firms) or activity of the network (degree to which the researchers use their contacts for purposes of research) (Van Rijnsoever et al, 2008) . This inter-relationship should be intense and productive. The collaborative research is a key mechanism for inter-linking distributed knowledge and skills in new ideas and opportunities for research. The necessity for effective flow of knowledge between institutions in emerging areas of research such as nanotechnology and a challenge for public search (Heinze; Kulhlman, 2008). For nanotechnology, the multidisciplinary aspect is important, what stands out even more the spirit of the network. The results refer to in terms of scientific publications, patents, collaborative projects, but also other aspects can be considered as intangible: the type or form and frequency of interactions (Meyer, 2006, p.1658; Meyer-Krahmer; Schmoch, 1998). This process is the basis of knowledge of the network. This knowledge is the basis of support for the following scale that is the technology transfer. The key actors in this size are researchers from universities, laboratories, research centers in private, both national and international This dimension includes four performance factors, each one contain indicators. Then it is describe the factors and examples of some indicators:

This dimension includes four performance factors, each one containing indicators. Then is described the factors and examples of some indicators:
• The classic indicators of cooperation, which can be classified into intra-institutional cooperation, inter and with private companies. These sub factors can be measured by the number of publications, joint publications, factors of impact (number of citations), accepted patents, collaborative projects, etc.. These indicators measure the quality of basic knowledge of the network (Youti, Shapira, 2008, p. s / n). • Strategy of the network: this factor assesses the organization's strategic network, that is, building a collective vision where members of the network understand as a creative source of value for the future of the institution and country. The indicators should be related to the type of strategy (exploration and exploitation), type of project (short and long term), type of innovation (incremental, radical, and so on.) Reach of network (national, international, etc.). (Luggen, et al., 2005; Germunden; Heydebreck, 1995).

- Indicators of competence in network: that measures the skills to handle, use and exploit the collaborative relationships between organizations (RITTER; GERMUNDEN, 2003). Some examples of the types of indicators are: centrality (connectivity between the actors) (Powell et al, 2005; Uzzi, 1996, 1998; Teece, 1986), intensity of relations (strong and weak ties) (Granovetter, 1973, Walker et al , 1997) and capital (level of trust between the actors) (Rycroft, 2002), types of learning (Gregersen; Johnson, 2005) and absorption capacity (Cohen Levinthal, 1990).
- Indicators of governance of the network: those which are related to the administrative structure of the network, the mechanisms of internal coordination, internal policies, etc.. Some examples of indicators are: quality of the policies of mobility of researchers, distribution of financial resources, and distribution of royalties for innovation, to encourage the innovation potential, quality of management tools to support and information systems available, the use of ICTs in interactions and so on. (Provan; KENIS, 2005, WARKETIN, 2001)

3. Technology Transfer.- Here are considered activities related to technology transfer and the various mechanisms used by the network with the aim of that knowledge and technologies (innovations) come to be marketed. The mechanisms can be both direct as indirect. They are direct when universities and research institutes to take his third mission, the entrepreneurial (Leydesdorf; Etzkowitz, 1998) and form its technology-based companies by teachers or students (spin-offs) and take charge of marketing directly to the industry. They are indirect, when the universities or research centers in use various agents in order that they take responsibility for getting innovations to the industry (agencies on technology transfer, innovation agencies, lawyers, parks, science, etc.). The achievements are assessed in terms of spin-offs, spin-outs, subject patents, licensed patents and so on. The actors are the key researchers' entrepreneurs (spin-offs) and the agents of innovation. The process of technology transfer is to support an innovative knowledge. It also includes here the factor of international visibility of the network. This dimension includes three performance factors, is a technological innovation, technological entrepreneurship other is the third international visibility .

The indicators for this factor are:
• The number of licensed patents in industrial use that represent the innovative potential of innovative researchers. (Wartburg; Teichert, 2007, p s / d)
• The number of co-patents. The co-patents represent the highest level of maturity of a collaborative venture, in this case the network. (Kim; Song, 2007).
• The number of spin-offs. - It is the entrepreneurial ability of universities to create technology-based companies from the search. For this process to be developed is necessary to support the venture capital and managerial skills on the part of researchers.
• The position of the international network. - International recognition and attractiveness of the network

4. Manufacturing and Marketing in scale. - If you analyze the activities of scale in manufacturing and marketing of innovations of the network (is related to the type of technology transfer centre or adopted by the University of Public Research). Here are analyzed the level of support of the "Venture Capital" to support the marketing of innovations, as well as the interactions of centers of research with industry to support joint projects of marketing innovations. The results refer to in terms of products or services sold in nanotechnology, to support enterprises to venture capital and so on.
5. Demands. - Are analyzed aspects of demands, impacts on society, levels of information, among others, products and innovations in nanotechnology in the market (not because the demand in economic terms). The actors are key users of products with nanotechnology. The results refer to in terms of consumer satisfaction, levels of claims, etc.

It is emphasized that this research don't considers the latter two dimensions will not be examined thoroughly, since the scale in production, marketing, and demand attention, belong to networks from the perspective of the industry. However, the public network should have a system for tracking the demand and to search within benchmarks for security of human health and environment. Follows a summary of the continuation dimensions, critical factors and examples of some proposed indicators

Table 3. Description of the dimensions and factors and indicators

Dimensões	Fatores de desempenho	Exemplos de Indicadores
I. Ambiente Externo da Rede Considera a Orientação estratégica e os mecanismos de política pública para suportar inovação em Nanotecnologia. Considera-se também a trajetória tecnológica	• Orientação Estratégica Nacional de Nanotecnologia	• Plano Estratégico país para nanotecnologia (longo prazo). • Programas nacionais a curto-médio prazo nanotecnologia
	• Política de Inovação no contexto SIN (ambiente para inovação em rede) • Marcos legais em Nanotecnologia • Marcos regula tórios: sistema de propriedade intelectual. • Métricas . certificação. • Fundos públicos • Capital de risco • Infra-estrutura – Laboratórios • Apoio para formação de RRHH. • Programas de difusão e treinamento, empreendedorismo, redes etc. • Cooperação Internacional • Trajetória tecnológica país	• Incentivos fiscais para P&D • Subvenções para P&D • Sistemas de Propriedade Intelectual • Métricas-estándares • Fundos alocados • Disponibilidade de capital risco • Gastos em infra-estrutura laboratórios • Gastos in infra-estrutura TICs • Gastos em educação superior • No de eventos treinamento a redes • No de eventos difusão nano • No de parcerias /convênios internacionais assinados • Cultura inovação, tradição do pais em inovação
II. Processo de inovação em rede, Avalia-se a capacidade de gerar conhecimento e inovação em rede, através da Interação, cooperação, sinergias entre agentes e instituições de pesquisa pública e firmas. .	• Estratégia da rede alinhada com a Estratégia Nacional e estrutura	• Visão coletiva • Plano estratégico da rede
	• Competência em rede (habilidades e atividades para influenciar na rede)	• Centralidade • Nível de capital social • Capacidade de absorção • Freqüência de interações • Tipo de interações (físicas, virtuais)
	• Cooperação tecnológica em rede. • Cooperação pesquisadores intra-universidade (nos seus diferentes centros, institutos) • Cooperação pesquisadores públicos inter universidades da rede • Cooperação pesquisadores públicos e P&D firmas- inter institucional	• No de projetos colaborativos.. • Número de doutores, pós-doutores, mestres, iniciação científica formados.. • No. de publicações. • No. de co-publicações • No. de wokshops • No de projetos colaborativos • No de co-publicações • Freqüência de interações • No. de férias nanotec • Freqüência no uso de laboratórios da rede • Uso racional e eficiente infra-estrutura

	• Governança da rede e instrumentos gerencias de apoio	• Mecanismos de coordenação • Mecanismos de comunicação • Políticas.internas asignação de recursos • Políticas internas mobilidade • Políticas internas distribuição *royalties*. • Sistemas integrados informação em redes • Sistemas de gestão do conhecimento • Sistemas de auto-avaliação • Sistemas de monitoramento • Ambientes virtuais
III. Transferência tecnológica e científica da rede (Impactos) Atividades relacionadas com a transferência de conhecimento e tecnologias com o objetivo de que cheguem a serem fabricadas em escala e posteriormente comercializadas.	• Impacto industrial da rede • Empreendedorismo tecnológico Visibilidade internacional	• Patentes submetidas • Co-patentes (Universidade e Indústria) • Patentes licenciadas (Uso industrial) • No de Spin *Offs* Ranking internacional
IV Fabricação em escala e Comercialização capacidade de fabricar em escala e comercializar inovações..		• Produtos da rede comercializados pela indústria em grande escala.
V Segurança e ambiente Atención de diferentes demandas de usuarios y de la sociedad..		• Reclamos da sociedade por falta de segurança na saúde e no ambiente dos produtos baseados em nanotecnologia

.3. How to evaluate the networks.

A prerequisite for this method of assessment work is that there must be an environment of innovation, supported by public policies and strategies of the country that allow this process to be viable. The evaluation process using the proposed model will build on the work of Polt and Rojo (2002) and defined in INNOVATION (2004). In the latter work the process is based on stages (See Illustration 14). Each stage has its own types of assessment and associated indicators that characterize. For this assessment helps in the formation of a culture of innovation, it would be interesting to draw this process, of incentive programmes.

The stages can be defined as follows:

1.Phase or beginning or implementation. This stage can have duration of up to 2 years. For a network at this stage is necessary between the definitions of their strategies, materialized in a strategic plan for the proposal that the network is necessary to accept that it is supported by an evaluation Ex-ante (See Section 2.4.1). In developing this stage can be made assessments in real time (through the analysis of the network, to evaluate its momentum) by the members of the network. At the end of this period the network is measured by average of a report and workshops. At the end of this phase, the network must have at least collaborative projects between centers, a reasonable number of scientific publications and students in the training process. This assessment can be made through a mid-term.

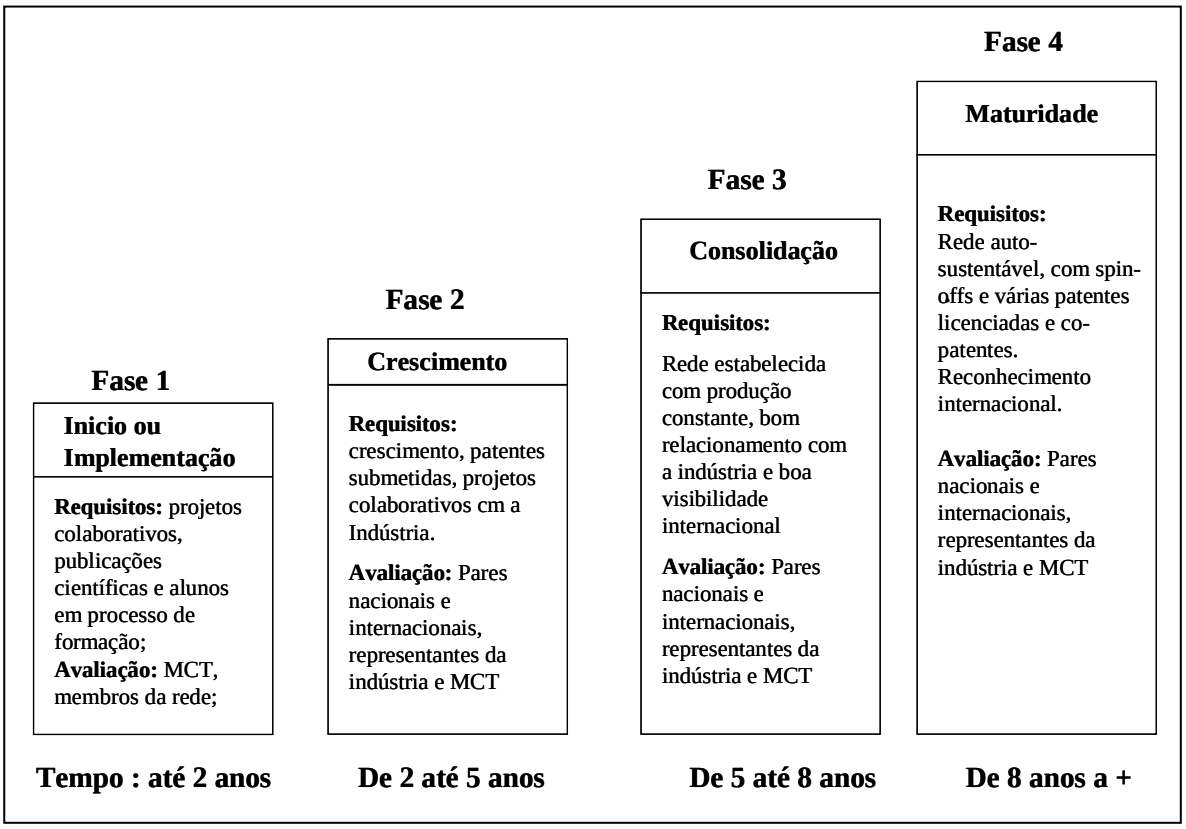


Fig. 2 – Assessing networks- Phases

2. Phase of Growth. At this stage is already requires a range of targets set at the time of creation of the network. She must have grown, both in its production of knowledge as in its size (number of actors). At this stage, the coordinators, to improve its management of the network, need assessments in real time, using techniques of social networks and analysis of statistical data, supported by software. An example of this type of software is the software Pajeck (Cross; Parker, 2004) that allows you to create a map of the network. This kind of assessment gives an overview of the relationships between the actors participating in it of its analysis to find weaknesses in communication and relationships. Detected these problems is possible to take actions to improve, for example, flows of information, dissemination of innovation and collaborative activities, contributing to improved connectivity of the actors (Cross; Parker, 2004). You can also get patterns of behavior at the end of this stage is carefully analyzed the process and the network are required products as patents submitted and collaborative projects with industry. This is important in the case of Brazil, where the networks of nanotechnology have been created in order to turn that knowledge technology (MCT, 2007). At the end of this phase, or biennial, it is necessary to make a mid-term; it would be advisable that were made by peers outside national and international, and industry representatives.

3**. Phase of Consolidation**. At this stage the network now must be consolidated, that is, it must have a tendency to be self-sustaining. Public funds are increasingly less able to survive. The production of knowledge of this network has to be constant and it must have a good relationship international (visibility) and the industry (licensed patents) and at least project of creating spin-offs. At the end of this phase, or biennial, it is necessary to make a mid-term; it would be advisable that were made by foreign national and international peers and industry representatives.

4**. Stage of Maturity.** The network becomes self-sustainable and generates its own resources. Several spin-offs have been created and there are several licensed patents and even co-Patents. At the end of this phase, the network must have international recognition. At the end of this phase, or biennial, it is necessary to make a mid-term, it would be advisable that were made by foreign national and international peers and industry representatives.

In all these stages, as can be seen, an assessment should be done in real time, and intermediary evaluations at the end of each stage. It would be desirable for evaluation Ex ante, is made not only at the beginning of the creation of the network but also for their development. It should be clear that the evaluation process should be a process of learning rather than punishment (VINNOVA, 2004).

6. Conclusions and guidelines for future works

The innovations in networks are considered a contemporary form of value creation. They are a product of globalization. Innovation includes contemporary concepts such as collaboration, synergy and demand new skills. It also implies a cultural change and even a change in mentality. The networks are based on the premise that organizations can no longer innovate more in isolation and limited to his department of P & D, but they need to interact with the environment for external access to knowledge. Meanwhile due to its complexity and high coordination efforts, these networks require support of managerial tools for example those associated with the evaluation of their performance. Without the support of these tools that task becomes even more complex and elusive.

In this context appears the Nanotechnology, which by its nature is dynamic, multidisciplinary rand requires networks to promote its innovative potential. Many countries around the world, both developed and in development, are running programs and strategies in nanotechnology and especially in public networks of innovation, since these are considered powerful tools of public policy through its dynamism and contribute to the strengthening of the innovation system. However, some years have been spent since the deployment of these networks and interest in what its innovative potential has emerged ever more frequently. Unfortunately, there are scarce in the literature with regard to the evaluation of networks. Some efforts have been made, but in general they are scarce and often linear, fragmented and without considering the dynamic nature of network.

With the aim to contribute in any way to fill this gap, it has proposed a conceptual model to support the assessment of networks of innovation in nanotechnology from the perspective of public research and in the context of innovation systems. It was developed based on three dimensions, some critical factors and examples of indicators for each factor. Moreover, the methodological proposal associated with the conceptual framework, used the national innovation conceptual framework. The evaluation process considers elements of traditional assessment (ex ante and ex-post, and currently evaluation), this has involved not only consider the networks in terms of traditional assessment of final results (ex-post), but also evaluate the process of innovation in network and suggesting the necessity for ex-ante, on a permanent basis, with the aim of monitoring the environment and technological trends.

This proposal was based in the literature and empirical research in three segments of the Brazilian nanotechnology network. From the literature it was identified critical

performance dimensions and factors to be considered within the model, thus resulting in the definition of three assumptions, described below:

Assumption 1. The environment of the network influence their performance,
Assumption, 2. The network processes influence the performance of the network,
Assumption 3. The process of technology transfer influence the network performance.

From this point of view, the work was focused on demonstrating the above assumptions through an empirical research both qualitative as quantitative. It was developed with experts and researchers from some existing networks of nanotechnology in Brazil. The results of this research confirmed the importance of these dimensions and factors identified and were initially detected some factors as very important. Some results are the attention given a factors like: the national nanotechnology strategy, the strategy of each network, the network competences, the collaborative relationships between public and private research and the technology transfer.

It is hoped that the proposal can be particularly useful for academics, practitioners, and policy makers in order to guide empirical studies in innovation networks and to improve their technological strategies and Science & Technology policies. It is also expected that the proposal will be replicated in others sectors and the framework can be also extended to evaluate private networks.

Future works.-

As guidelines for future work, may be mentioned the following:

• It is important to develop research into more segments of the Brazilian nanotechnology network, allowing greater extent in the processing of data through a non-parametric statistical analysis with a larger sample size, using models of structural equation (Skrondal; Rabe-Hesketh , 2004, ch. 4) and factor analysis (Barroso; Arts, 2008). This study could facilitate a more accurate definition of the importance of factors as the performance of networks and therefore define weights and measurements to the factors and indicators allowing the construction of a more appropriate tool for evaluation of networks enabling detect, among other things, their levels of maturity or its current situation. This may facilitate also comparative studies..

• Develop software tools that enables support the evaluation network process in partnership with researchers in the field of Computer Science. A multidisciplinary study in the area of social networks may be useful for the development of tools to support the networks of innovation in nanotechnology that can be extended to other areas.

• This proposal is an initial research point in order to develop studies for example related the emergence of innovation sectoral nanotechnology system.

• Research about the management of innovation networks, nowadays is scarce, so can be a very fertile field for research.

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